HYDROELECTRICITY CONSUMPTION AND ECONOMIC GROWTH NEXUS: TIME SERIES EXPERIENCE OF THREE AFRICAN COUNTRIES

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Abstract

This paper examines the relationship between hydroelectricity and economic growth for three African countries within a multivariate framework over the period 1980-2009. Our results provide support for the neutrality hypothesis for Egypt. The feedback hypothesis is confirmed in Algeria while the conservation hypothesis is supported in South Africa. These findings imply that the authorities in Egypt and South Africa can implement conservation policies which seek to reduce hydroelectricity consumption without adversely affecting their economies' growth rates. The same cannot be said for Algeria where there is evidence of bi-directional causality between the two variables.

Keywords: Algeria, Egypt, economic growth, Granger causality, hydroelectricity, seemingly unrelated regression, South Africa

Introduction

A number of studies have analyzed the causal relationship between electricity consumption and economic growth in different countries (see Wolde-Rufael, 2006; Narayan and Singh, 2007; Altinay and Karagol, 2005; Ghosh, 2002; Ziramba, 2009 among others). The results of these studies vary greatly from country to country. There is also a growing literature on the causal relationship between electricity consumption and economic growth in African countries (see Jumbe, 2004; Wolde-Rufael, 2006; Odhiambo, 2009; Ziramba, 2009 among others). Despite this growing literature none of these studies has considered how the electricity is generated. With the world facing global warming mainly as a result of the consumption of fossil fuels, it might be important to consider hydroelectricity which is non-polluting. To the best of our knowledge, the only study to have considered the impact of hydroelectricity on economic growth is by Abakah (1993) for Ghana. This is now an old study. We seek to add to this growing literature by extending the analysis to three other African countries using more recent data.

The purpose of this paper is to test the causal relationships between hydroelectricity consumption and economic growth in three African countries, namely Algeria, Egypt and South Africa using a modified version of the Granger causality developed by Toda and Yamamoto (1995). The empirical analysis employs annual data for the period 1980- 2009.

The remainder of the paper is organized as follows: the next section gives an overview of the hydroelectricity sectors in the three countries. Section 3 reviews a selection of some of the empirical studies on the electricity consumption-economic growth nexus. Section 4 outlines the empirical model specification used in this paper. The econometric techniques which are employed in this study are discussed in the same section. Section 5 presents the empirical results of the study. The final section summarizes the main findings of the paper and gives some policy implications.

An overview of the electricity sectors in the three countries

Algeria's largest source of electricity generation is natural gas. This energy source accounts for 97 percent of the country's electricity supply. The remainder comes from hydroelectricity. Electricity generation, transmission and distribution used to be controlled by the then state-owned company, Sonelgaz. The sector has been liberalized and Sonelgaz has been privatized. Over the past decade there have been developments to pursue the development of alternative sources of electricity like solar, wind and biomass (Energy Information Administration, 2010). Algeria exports excess supply to Morocco and Tunisia.

The Egypt has one of the highest rate electricifation in the continent. As at 2007 the country had an installed capacity of 22.6 Gigawatt (GW), most of which (19.3 GW) was generated from thermal generation and 2.8GW being generated from hydroelectricity and the remaining 0.3 GW coming from wing generation capacity (Energy Information Administration, 2010). Egypt has a well developed hydroelectricity sector. In 2007 Egypt generated 17 billion kilowatt hours (BKwh) from hydroelectric resources (Energy Information Administration, 2010).

South Africa has a well-developed electricity production and distribution capabilities which were inherited from the previous political system. Electricity is supplied to consumers by a monopolized public utility known as Eskom. It is mainly generated from coal-fired power stations. In 1999 the country has 38 power stations and 23 coal-fired power stations which accounted for 87 percent of the then total installed capacity (Davidson et al., 2002). The other significant electricity source is nuclear. Renewable energy plays a limited but significant role in power generation, particularly hydroelectric power generation. South Africa has two systems of hydro-power generation: the conventional hydro and the pumped storage. The pumped storage system involves using surplus electricity to pump water to a mountain top reservoir during off-peak periods. This water plays an important role of stored "electricity" which can be used to regenerate electricity to meet unexpected demands or a sudden breakdown at a baseload power station. The country's abundant sunshine is only beginning to be tapped in more remote areas for electricity generation for domestic and institutional applications (Department of Minerals and Energy, 2006).

A review of the electricity- growth literature

Empirical evidence on the causal relationship between energy consumption and income or output has been rather mixed. This evidence has been synthesized into four testable hypotheses; the growth hypothesis, the conservation hypothesis, the feedback hypothesis and the neutrality hypothesis (Payne, 2008). The growth hypothesis suggests that energy consumption contributes to economic growth, both directly and indirectly, as a complement to other inputs in the production process. Support for this hypothesis requires unidirectional causality from energy consumption to income. The conservation hypothesis states that energy conservation policies that curtail energy consumption would not adversely affect real income. Unidirectional causality from income to energy consumption provides support for this hypothesis. The feedback hypothesis says that energy consumption and income are interdependent and requires bi-directional causality between the two variables. Lastly, the neutrality hypothesis implies that energy consumption has a minor role in the determination of real income (Payne, 2008). This hypothesis is supported if there is no Granger-causality between energy consumption and real income or output.

As pointed out earlier the only study that has analyzed the impact of hydroelectricity on economic growth is by Abakah (1993). The study assesses the relationships between economic growth and three sources of energy- charcoal, petroleum and hydroelectricity in Ghana over the period 1976- 1990. The study's results indicate a significant negative correlation for charcoal and positive correlation with respect to the consumption of hydroelectricity and petroleum.

Jumbe (2004) uses Granger causality and error correction techniques to examine cointegration and causality between electricity consumption and, respectively, overall GDP, agricultural GDP and non-agricultural GDP in Malawi over the period 1970-1999. The author found cointegration between electricity consumption and, respectively overall GDP and non-agricultural GDP, but not with agricultural GDP. The study's causality test results suggest bidirectional causality between electricity consumption and overall GDP, but unidirectional causality from non-agricultural GDP to electricity consumption. Their ECM results detect unidirectional causality, with causality running from both overall GDP and non-agricultural GDP to electricity consumption.

Altinay and Karagol (2005) investigate the causal relationship between electricity consumption and real GDP in Turkey during the period of 1950-2000. They employed the Dolado-Lutkepohl test using the VARs in levels as well as the standard Granger causality test using detrended data. Both tests yielded strong evidence for unidirectional causality from electricity consumption to income.

In a study on 17 African countries (including Algeria, Egypt and South Africa) Wolde-Rufael (2006) looked at the long-run and causal relationship between electricity consumption per capita and real GDP per capita for the period 1971-2001. The author's empirical evidence shows that there was a long-run relationship between electricity consumption per capita and real GDP per capita for only 9 of the countries and Granger causality for only 12 countries. For 6 countries there was a positive uni-directional causality running from real GDP per capita to electricity consumption per capita. There was reverse causality in 3 other countries and bi-directional causality for the remaining 3 countries. The study finds a long-run relationship between electricity consumption and real GDP for South Africa but not for Algeria and Egypt. The study causality test results indicate no causality in either direction in Algeria and South Africa. There was evidence of bi-directional causality in Egypt.

Odhiambo (2009) examines the causal relationship between electricity consumption and economic growth in South Africa over the period 1971- 2006. The author uses employment rate as an intermittent variable in the bivariate model between electricity consumption and economic growth. The study's empirical results show that there is bidirectional causality between electricity consumption and economic growth in South Africa. Employment was found to Granger cause economic growth. These causality results were found to apply in both short-run and long-run periods.

Narayan and Singh (2007) investigate the nexus between electricity consumption and economic growth for Fiji within a multivariate framework through including the labour force variable. They examine the long-run relationship using the bounds test approach. Their Granger causality results suggest that in the long-run causality runs from electricity consumption and labour force to GDP.

Ziramba (2009) assesses the relationship between various forms of energy consumption and industrial output in South Africa by undertaking a co integration analysis with annual data over the period 1980-2005. The study also investigates the causal relationships between the various disaggregate forms of energy consumption (electricity, coal and oil) and industrial production. The results imply that industrial production and employment are long run forcing variables for electricity and oil consumption. Applying the Toda-Yamamoto (1995) technique to Granger causality, the study finds bi-directional causality between oil consumption and industrial production. For the other forms of energy consumption there is evidence of the energy neutrality hypothesis.

Methodology

Cointegration

In the literature a number of studies have applied co-integration analysis in assessing the relationship between energy and income or output (see Wolde-Rufael 2006, Jumbe 2004, Ziramba 2009, among others). In this study we use the Engle and Granger (1987) approach to cointegration to analyze the long-run relationship between hydroelectricity consumption, capital and real GDP per capita in a multivariate framework in three African countries, Algeria, Egypt and South Africa.

The following equation is estimated to determine whether a long-run equilibrium relationship exists:

$$\ln Y_t = \beta_0 + \beta_1 \ln E_t + \beta_2 \ln K_t + \varepsilon_t \qquad (1)$$

Where Y_t is real gross domestic product (GDP) per capita in period t, E is hydroelectricity consumption per capita, K is capital stock per capita, ε standard error term which is assumed to be white noise and all variables are in natural logarithms.

The null hypothesis of no cointegration, ρ = 1 is tested by conducting the following unit root test on the residuals (where $\varepsilon_t = \ln Y_t - \beta_0 - \beta_1 \ln E_t - \beta_2 \ln K_t$) from equation (1) as follows:

$$\varepsilon_t = \rho\varepsilon_{t-1} + \upsilon_t \qquad (2)$$

Toda-Yamamoto approach to Granger-Causality

We employed Granger non-causality tests by using a modified Wald (MWALD) test proposed by Toda and Yamamoto (1995). This procedure has been found to be superior to ordinary Granger-causality tests when testing for causality. Their procedure involves the determination of dmax, the maximal order of integration of the series in the model. The underlying model of the causality test is intentionally over-fitted with additional dmax lags, so that the VAR order is now p = k + d, where k is the optimal lag order. This ensures that the usual t-statistics for Granger-causality have standard asymptotic distributions. The procedure utilizes a modified Wald test statistic (MWALD) for the restrictions on the parameters of VAR (k), where k is the lag length in the system. The MWALD statistic has an asymptotic chi-square distribution when VAR (k + dmax) is estimated. To undertake Toda and Yamamoto's version of the Granger non-causality test, we represent the industrial production-energy consumption model in the following VAR system:

$$\ln Y_t = \alpha_0 + \sum_{j=1}^{k+d\max} \alpha_{1j} \ln Y_{t-j} + \sum_{j=1}^{k+d\max} \alpha_{2j} \ln K_{t-j} + \sum_{j=1}^{k+d\max} \alpha_{3j} \ln E_{t-j} + \varepsilon_{1t} \qquad (3)$$

$$\ln E_t = \beta_0 + \sum_{j=1}^{k+d\max} \beta_{1j} \ln Y_{t-j} + \sum_{j=1}^{k+d\max} \beta_{2j} \ln K_{t-j} + \sum_{j=1}^{k+d\max} \beta_{3j} \ln E_{t-j} + \varepsilon_{2t}, \qquad (4)$$

$$\ln K_t = \lambda_0 + \sum_{j=1}^{k+d\max} \lambda_{1j} \ln Y_{t-j} + \sum_{j=1}^{k+d\max} \lambda_{2j} \ln K_{t-j} + \sum_{j=1}^{k+d\max} \lambda_{3j} \ln E_{t-j} + \varepsilon_{3t} \qquad (5)$$

where the series are as defined above and ε_{1t}, ε_{2t} and ε_{3t} are error terms that are assumed to be white noise. The system is estimated using the seemingly unrelated regression (SUR) technique. The Toda and Yamamoto (1995) procedure has an advantage in that it does not require precise knowledge of the integration properties of the system. It can be applied even when there is no integration or stability, and when rank conditions are not satisfied 'so long as the order of integration of the process does not exceed the true lag length of the model' (Toda and Yamamoto, 1995).

Based on equations (3) - (5), the following causal relationships between coal consumption, capital and economic growth can be tested:

Table 1. Causal relationships

Causal flow	Conditions
(1) electricity consumption (E) → economic growth (Y)	$\alpha_{3j} \neq 0$; j =1,….k
(2) Capital (K) → economic growth (Y)	$\alpha_{2j} \neq 0$; j =1,….k
(3) electricity consumption (E) → Capital (K)	$\lambda_{3j} \neq 0$; j =1,….k
(4) Economic growth (Y) → capital (K)	$\lambda_{1j} \neq 0$; j =1,….k
(5) Economic growth (Y) →electricity consumption (E)	$\beta_{1j} \neq 0$; j =1,….k
(6) Capital (K) → electricity consumption (E)	$\beta_{2j} \neq 0$; j =1,….k

Empirical analysis and results

Data, sources and univariate properties

Annual data for the period 1980-2009 for hydroeleceticity consumption (E) measured in Kilowatt hours (KWh) were obtained from BP (2010), population figures (in millions) were obtained from Energy Information Administration for Algeria, Egypt and South Africa, while real GDP per capita (Y) and real gross fixed capital formation per capita (K), both measured in constant local currency unit, were obtained from the World Development Indicators, CD-ROM. All variables are expressed in natural logarithms. Some descriptive statistics for the countries under consideration are presented in Table 2.

Table 2 Some basic statistics

	Real GDP per capita				Hydroelectricity consumption per capita				Gross capital formation per capita			
	Mean	Min	Max	Std. Dev.	Mean	Min	Max	Std. Dev.	Mean	Min	Max	Std. Dev.
Algeria	9.07	8.9	9.2	0.08	2.12	0.6	3.4	0.72	7.63	7.3	8.3	0.27
Egypt	7.82	7.5	8.2	0.21	5.27	5.1	5.5	0.10	6.50	6.0	7.0	0.23
RSA	10.36	10.3	10.5	0.08	3.39	1.3	4.4	0.65	8.41	8.1	9.0	0.26

Source: Author's calculations from WDI 2010 and BP 2010.

In order to obtain an estimate of the maximum order of integration to use in the Toda-Yamamoto tests for Granger causality, we analyzed the stationarity properties of the series. A stationary series is characterized by a time-invariant mean and a time-invariant variance. There are alternative methods that are used to test for the univariate properties of a time series. In this study we use the Dickey-Fuller GLS test developed by Elliott et al. (1996) to examine the unit root properties of the data. Tables (3a-3c) present our unit root test results for the three countries. These results reveal that the null hypothesis of unit root is not rejected in levels for all variables in all countries, but is rejected in first differences for all variables except in the case on capital stock in the case of Algeria. This variable was found to be integrated of order two. The unit root test results show that the highest order of integration is one for Egypt and South Africa while for Algeria it is two. Thus, dmax = 1 for Egypt and South Africa, while it is equal to 2 for Algeria.

Table 3a. Unit root test results: Algeria: DF-GLS

Variable	Levels		First differences	
	Intercept	Trend & intercept	Intercept	Trend & intercept
lnE	-2.748***	-3.354***	-8.152***	-8.601***
	(-2.647)	(-3.190)	(-2.650)	(-3.770)
lnY	-1.095	-1.330	-2.849***	-3.111*
	(-1.610)	(-2.890)	(-2.650)	(-2.890)
lnK	-0.656	-0.058	-1.107	-2.617
	(-1.610)	(-2.890)	(-1.610)	(-2.890)

*****,**,* denote significance at the 1%, 5% and 10% level respectively. The numbers in the parentheses for the insignificant tests are the critical values at 10% level.**

Table 3b. Unit root test results: Egypt: DF-GLS

Variable	Levels		First differences	
	Intercept	Trend & intercept	Intercept	Trend & intercept
lnE	-1.608	-1.850	-4.755***	-4.770***
	(-1.610)	(-2.890)	(-2.650)	(-3.770)
lnY	0.173	-2.397	-3.646***	-3.795***
	(-1.610)	(-2.890)	(-2.650)	(-3.770)
lnK	-1.953*	-2.018	-3.354**	-3.188***
	(-1.610)	(-2.890)	(-3.190)	(-2.650)

*****,**,* denote significance at the 1%, 5% and 10% level respectively. The numbers in the parentheses for the levels are the critical values at 10% level.**

Table 3c. Unit root test results: South Africa: DF-GLS

Variable	Levels		First differences	
	Intercept	Trend & intercept	Intercept	Trend & intercept
lnE	-3.995***	-4.106***	-6.736***	-7.141***
	(-2.647)	(-3.770)	(-2.650)	(-3.770)
lnY	-1.492	-1.837	-3.008***	-3.063*
	(-1.610)	(-2.890)	(-2.650)	(-2.890)
lnK	-1.446	-2.086	-2.460**	-3.358**
	(-1.610)	(-2.890)	(-1.953)	(-3.190)

*****,**,* denote significance at the 1%, 5% and 10% level respectively. The numbers in the parentheses for the levels are the critical values at 10% level.**

Cointegration test results and long-run elasticities

As we pointed out earlier, the basic idea behind the Engle-Granger (1987) approach to cointegration is to test whether a linear combination of individually non-stationary time series is itself stationary. With the univariate properties of the three series determined, we proceeded to test for cointegration as is specified in equation (2). The unit root test results on the residuals for both the augmented Dickey-Fuller (ADF) and Phillips- Perron (P-P) tests are reported in Table 4. The residuals are found to be stationary in Algeria and South Africa but not in Egypt. These results indicate the presence of cointegration among the three variables for Algeria and South Africa. The estimated elasticities with respect to both capital and oil consumption are positive but less than one and are statistically significant at 1 percent level. The presence of cointegration indicates causality in at least one direction but it does not say which one. Having found cointegration among the three series we proceeded to test for Granger causality.

Table 4 Results of unit root tests on the residuals of equation (1)

	ADF	P-P
Algeria	-1.881*	-1.973**
	(-1.610)	(-1.953)
Egypt	-0.652	-0.778
	(-1.610)	(-1.610)
South Africa	-1.818*	-1.850*
	(-1.610)	(-1.610)

****, * denote significance at the 5% and 10% levels, respectively. The numbers in the parentheses, where not significant, are the 10% critical values.**

Our long-run elasticity estimates estimated using the autoregressive distributed lag (ARDL) approach, are reported in Table 5. Both capital and hydroelectricity have positive elasticities. Capital has a significant impact in all three countries. Hydroelecticity has a significant impact on real GDP per capita only in Egypt and South Africa. These results indicate very low elasticities as indicated by the low parameter estimates.

Table 5 ARDL long-run elasticities: dependent variable lnY

	lnK	lnE
Algeria ARDL(2, 1, 1)	0.109**	0.008
Egypt ARDL(1, 0, 2)	0.044***	0.09**
South Africa ARDL (2, 1, 0)	0.36***	0.011*

*****, **, * denote significance at 1%, 5% and 10% level, respectively**

Granger causality results

To complement the cointegration results above, causality tests were carried out using the Toda-Yamamoto (1995) technique; the results are reported in Table 6. The optimal lag length of two was chosen on the basis of the unanimous indication by the Akaike information criterion (AIC), Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ). The significance of the p-values of the modified Wald (MWALD) statistic indicates the causal relationships. Our results show evidence of interdependence among the three variables. There is evidence of bidirectional causality between hydroelectricity consumption and economic growth and also between capital and hydroelectricity consumption in Algeria. Our result is similar to that by Wolde-Rufael (2006) who found no causal relationship between electricity consumption and real GDP per capita in Algeria over the period 1971-2001. In Egypt our results show that the only causal relation is a unidirectional causality from capital to economic growth. There is no evidence of causality between hydroelectricity consumption and economic growth in either direction. Wolde-Rufael (2006) found bi-directional causality between electricity consumption and real GDP per capita in Egypt. For South Africa our results indicate evidence of unidirectional causality from economic growth to both capital and hydroelectricity consumption. There is also evidence of unidirectional causality from capital to hydroelectricity consumption. Our results are different from those by Odhiambo (2009), who found bi-directional causality between electricity consumption and real GDP per capita over the period 1971-2006. Our causality for Egypt and South Africa highlight the need to disaggregate electricity consumption by source. They show that causal relationships between total electricity consumption and economic growth are not always consistent with disaggregate electricity consumption.

Table 6. Toda and Yamamoto Granger-causality test results

	lnE→lnY	lnE→lnK	lnY→lnE	lnY→lnK	lnK→lnE	lnK→lnY	Direction of causality
	p-value	*p*-value	*p*-value	*p*-value	*p*-value	*p*-value	
Algeria	0.044**	0.016**	0.098*	0.124	0.065*	0.341	E ↔Y E ↔ K
Egypt	0.172	0.696	0.693	0.822	0.333	0.002***	K →Y
South Africa	0.674	0.685	0.011**	0.008***	0.010**	0.483	Y →K Y →E K→ E

***, **, * denote significance at the 1%, 5% and 10% levels, respectively.

Concluding remarks and policy implications

The objective of this paper was to test the long-run and causal relationships between economic growth and hydroelectricity consumption in Algeria, Egypt and South Africa over the period 1980-2009. We achieved the objective by undertaking our analysis a multivariate framework by including capital.

We started by analyzing the time series properties of the data. For this purpose the DF-GLS test was used. Unit root tests confirmed that all variables in the model are non-stationary. We proceeded by testing for cointegration. Our cointegration test results suggest that there exists a long-run relationship between hydroelectricity consumption, real GDP and capital stock in Algeria and South Africa but not in Egypt. Capital has a significant positive impact on economic growth in the long-run. Hydroelectricity has a significant positive impact in Egypt and South Africa but not in Algeria.

Our long-run causality test results which suggest bi-directional causality between hydroelectricity consumption and economic growth in Algeria provide support for the feedback hypothesis. This finding highlights the complementary relationship between these two variables in this particular. The policy implication of this result is that energy conservation policies which seek to reduce energy consumption will adversely affect Algeria's economic growth rate. Our causality results for Egypt indicate no causal relationship between hydroelectricity consumption and economic growth. This finding confirms the neutrality hypothesis implies that hydroelectricity has a minor role in the determination of economic growth (real income) in Egypt. In this scenario, the reduction in hydroelectricity consumption through energy conservation policies will not impact economic growth. Our causality results for South Africa indicate unidirectional causality from economic growth to hydroelectricity consumption. This finding supports the conservation hypothesis which postulates that energy consumption is driven by economic growth. In this case conservation policies which seek to reduce the consumption of hydroelectricity will not adversely affect economic growth in South Africa

References:

Abakah, E. M., (1993). A review of economic growth and energy consumption in a developing country: Ghana. *OPEC Energy Review* 17 (1), 47- 61.

Altinay, G. and karagol, E. (2005). Electricity consumption and economic growth: evidence from Turkey. *Energy Economics* 27, 849- 56.

BP. The Statistical Review of World Energy (2010). <http://www.bp.com/statisticalreview> (accessed on 15th October 2010).

Brown, C.E., (2002). *World Energy Resources*. Springer, Berlin.

Elliott, G., Rothenberg, T., Stock, J., (1996). Efficient tests for an autoregressive unit root. *Econometrica* 64, 813-36.

Energy Information Administration, (2010). Electrical power in Algeria. www.eia.doe.gov/emeu/cabs/algeria. (Accessed on 25th September 2010).

Energy Information Administration, (2010). Country Analysis Briefs. June 2010.

Energy Information Administration, (2010). www.eia.doe.gov/. (Accessed on 25th September 2010).

Engle, R.F. and Granger, C.W.J., (1987). Co-integration and error correction:representation, estimation, and testing. *Econometrica* 55, 251-276.

Ghosh, S., (2002). Electricity consumption and economic growth in India. *Energy Policy* 30, 125-129.

Jumbe, C.B.L., (2004). Electricity consumption and GDP: empirical evidence from Malawi. *Energy Economics* 26, 61-68.

Kraft, J., Kraft, A., (1978). On the relationship between energy and GNP. *Journal of Energy and Development* 3, 401-403.

Narayan, P.K., Singh, B., (2007). The electricity consumption and GDP nexus for the Fiji Islands. *Energy Economics* 29, 1141-1150.

Odhiambo, N.M., (2009). Electricity consumption and economic growth in South Africa: a trivariate causality test. *Energy Economics* 31, 635-640.

Payne, J.E., (2008). On the dynamics of energy consumption and output in the US. *Applied Energy*, doi.10.1016/j.apenergy.2008.07.003.

Toda, H.Y., Yamamoto, T. (1995), "Statistical Inference in Vector Autoregressions with Possibly Integrated Processes", *Journal of Econometrics*, vol. 66, pp. 225-50.

Wolde-Rufael, Y., (2005). Energy demand and economic growth: the African experience 19 countries. *Journal of Policy Modeling* 27, 891-903.

Wolde-Rufael, Y., (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy Policy* 34, 1106-1114.

Wolde-Rufael, Y., (2009). Energy consumption and economic growth: The experience of African countries revisited. *Energy Economics* 31, 217-224.

Ziramba, E., (2009). Disaggregate energy consumption and industrial production in South Africa. *Energy Policy* 37 (6), 2214-2220.